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**Sniff and tell: the feasibility of using bio-detection dogs as a mobile diagnostic intervention for asymptomatic malaria in sub-Saharan Africa.**

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**Keywords: Bio-detection dogs; malaria; The Gambia**

## **Abstract**

### ***Background***

Bio-detection dogs (BDDs) are used in some high-income countries as a diagnostic intervention, yet little is known about their potential in low/middle-income countries with limited diagnostic resources. This exploratory study investigated the opportunities and implications of deploying BDDs as a mobile diagnostic intervention to identify people with asymptomatic malaria, particularly at ports of entry, as an important step to malaria elimination in a population.

### ***Methods***

A qualitative study design consisting of participant observation, five focus group discussions, and informal conversations was employed in The Gambia (April-May 2017). A disciplined German shepherd companion dog (not trained as a BDD) was introduced to research participants and their perceptions recorded. Field-notes and discussions were transcribed, translated and analysed thematically.

### ***Results***

Most research participants viewed positively the possibility of using BDDs to detect malaria, with the major advantage of being non-invasive. Some concerns, however, were raised regarding safety and efficacy, as well as cultural issues around the place of dogs within human society. The Gambia is a rabies-endemic country, and unfamiliar dogs are not usually approached, with implications for how research participants perceived BDDs. Understanding such concerns and working with local people to address such issues must be part of any successful strategy to deploy BDDs in new settings.

### ***Conclusions***

BDDs represent a potentially non-invasive diagnostic tool for the detection of asymptomatic or chronic malaria infections, particularly in areas with very low parasite rates. However, it is important to understand local concerns and work closely with communities to address those concerns. Wider deployment of BDDs will also require careful planning and sustained financial support.

## 1    **Introduction**

2

3    Bio-detection dogs (BDDs) are increasingly being deployed in high-income countries  
4    (HICs) as an efficient, reliable, and mobile diagnostic intervention to detect volatile  
5    biomarkers contained in samples of human breath, skin, and urine that are produced  
6    by particular diseases and health conditions. Recent trials have demonstrated that  
7    appropriately-trained dogs have the capacity to identify cancers of the lung, breast,  
8    bladder, and prostate.<sup>1–6</sup> Medical alert assistance dogs are also used on a one-to-one  
9    basis to provide advance warning of epileptic seizures and, for people living with  
10    type I diabetes, the onset of hypoglycaemia.<sup>7</sup> Very little is known, however, about  
11    the prospects for using BDDs in the Global South, where a lack of available,  
12    affordable and effective diagnostic technologies represents a major global health  
13    challenge.<sup>8–9</sup>

14

15    Malaria has been an exception to this diagnostic gap: the roll-out of Rapid Diagnostic  
16    Testing (RDTs) and Loop-mediated isothermal amplification (LAMP) kits have been  
17    major global health success stories, offering the possibility of effective diagnosis and  
18    treatment even in remote rural areas without laboratory facilities.<sup>10–11</sup> RDTs and  
19    LAMPs, however, are both invasive tests that require blood sampling, and are  
20    typically used for individuals suffering symptoms and actively seeking treatment.  
21    Asymptomatic individuals are unlikely to come forward for invasive testing,  
22    particularly in contexts where blood sampling may be met with suspicion and  
23    resistance due to fears of ‘blood theft’ and ‘blood-depletion.’<sup>12–14</sup>

24

1 This is problematic for two reasons. First, parasitic infections of any density can pose  
2 serious health risks, particularly for infants and children in resource-poor settings,  
3 including morbidity, co-morbidity, mortality, and infection transmission.<sup>15</sup> Second,  
4 the elimination of malaria requires that asymptomatic individuals, who constitute  
5 the 'human reservoir of infection',<sup>16</sup> are promptly identified and treated. BDDs may,  
6 therefore, offer a non-invasive opportunity to accurately screen for parasitaemia (in  
7 community settings and/or border crossings) by detecting malaria-specific volatiles<sup>17</sup>  
8 among asymptomatic carriers.

9

10 This article draws on data from qualitative research conducted in The Gambia during  
11 a proof-of-concept study to ascertain the ability of BDDs to identify asymptomatic  
12 malaria infections<sup>18</sup> in children. Our premise is that the deployment of laboratory-  
13 designed interventions in the field requires an appreciation of the social and cultural  
14 contexts of deployment. As such, this exploratory study investigates human-canine  
15 relations in the Gambia as a basis for assessing the feasibility of future BDD  
16 deployment.

17

## 18 **Materials and methods**

19

### 20 *Study site*

21 This research was conducted in collaboration with the Medical Research Council Unit  
22 in The Gambia at the London School of Hygiene and Tropical Medicine (MRCG). The  
23 Gambia is a small low-income country in West Africa with an ethnically diverse,  
24 Muslim majority, population. The research sites included rural villages in the Upper

1 River Region (URR) and urban settlements in the West Coast Region (WCR), (Figure  
2 1). The qualitative research presented here forms part of a larger proof-of-concept  
3 study, to ascertain whether trained BDDs could detect volatiles from biological  
4 samples of malaria-infected children. The goal of the qualitative research component  
5 was to explore how Gambians might perceive the use of dogs as a diagnostic  
6 technology.

7

## 8 *Malaria*

9 At the end of the malaria transmission season in November 2016, the prevalence of  
10 asymptomatic malaria infection in 5-13 year old school children in the study area  
11 was 7.9% (46/585) as determined by microscopy. In rural Gambia clinical episodes of  
12 malaria are diagnosed using antigen-detecting rapid diagnostic tests or stained blood  
13 slides read using microscopes, both methods require a finger-prick sample of blood  
14 to be taken. Both RDTs and microscopy are sensitive methods for detecting clinical  
15 malaria where parasite densities are high (2000 or 5000 parasites/ $\mu$ L), they are less  
16 sensitive at low parasite densities.<sup>19-20</sup> Moreover, strains of parasite have been  
17 detected that do not produce histidine rich protein 2, an antigen commonly used in  
18 RDTs, resulting in false negatives.<sup>21-22</sup>

19

## 20 *Qualitative research*

21 The qualitative research was conducted in April-May 2017. Initial ethnographic  
22 observations of human-dog interactions in public spaces were conducted, alongside  
23 a series of informal conversations on human-canine relations in local mosques,  
24 churches, pharmacies, health facilities, schools and local neighbourhoods (in both

1 rural and urban sites). These informed the design of a semi-structured focus group  
2 discussion (FGD) guide to obtain more detailed information on attitudes towards the  
3 possibility of using BDDs for malaria diagnosis.

4

5 Five FGDs were then conducted in three rural villages (URR), with 18 female and 17  
6 males participants (all over 18 years of age) from the three dominant ethnic  
7 backgrounds (Mandinka, Fula, and Serahuli); all but one were single-gender groups.  
8 Participants were recruited by MRCG field-workers in discussion with local *alkalos*  
9 (village heads). One limitation of this study is, therefore, that participants were not  
10 necessarily fully representative of other villagers, particularly those from minority  
11 ethnic backgrounds. As an exploratory study, however, this approach enabled us to  
12 quickly garner a reasonable spectrum of perspectives.

13

14 The focus groups proceeded as follows. After project sensitisation,  
15 participants were asked to discuss their experiences of, and attitudes towards, dogs  
16 in general before focussing more specifically on BDDs. The concept of BDDs was then  
17 raised by presenting a series of photographs showing working dogs in action, with  
18 the specific breeds (Springer Spaniels and Labradors) used by the UK-based  
19 collaborating charity Medical Detection Dogs. A well-behaved adult German  
20 shepherd ‘companion-dog’ was introduced in three of the five focus groups in order  
21 to elicit post-exposure perceptions. The dog was dressed with a branded red coat  
22 worn by working BDDs in the UK, and walked using a harness and lead at all times.

23

1           The companion dog was also introduced to residents of three extended-  
2 family compounds, and to staff and pupils in a rural school serving primary and  
3 secondary-aged students. On one occasion the dog was led (by a handler) down a  
4 stationary line of research participants, mimicking the use of police dogs to identify  
5 criminal suspects, in order to observe people's reactions and provide a focus for  
6 further discussions (Figure 2). The current protocol of Medical Detection Dogs is  
7 identification using biological samples ('sample method'), but trialling a 'line-up  
8 method' was important to generate perceptions of BDDs as a *mobile* diagnostic  
9 technique. It is important to note that this German Shepherd companion-dog was  
10 the most appropriate substitute for a 'foreign' BDD at our disposal in The Gambia; all  
11 study participants were made aware that the dog was not a trained BDD.

12  
13           All FGDs were convened by the lead author and were audio-recorded. MRCCG  
14 Fieldworkers facilitated the discussions in Mandinka, Serahuli and Fula, providing  
15 real-time English translations. Other MRC staff checked the quality and consistency  
16 of translations. Detailed observational field notes were kept, alongside information  
17 from informal interviews and discussions. Analysis proceeded on the basis of  
18 Grounded Theory,<sup>23</sup> whereby theoretical insights emerge from the data rather than  
19 being pre-imposed. All transcripts and field-notes were read and re-read closely by  
20 two of the authors, to identify patterns and key themes for coding (performed  
21 manually in Word).

22  
23           Informed consent was obtained verbally both from settlement leaders and  
24 individually from all study participants, in line with the Association of Social



1 Anthropologists (ASA) Ethical Guidelines.<sup>24</sup> MRCG fieldworkers presented the project  
2 orally in the relevant languages (Mandinka, Fula, and Serahuli), ensuring that  
3 prospective research participants understood the purpose of the research, the  
4 procedures involved, and their right to withdraw at any point. The study was  
5 approved by the Gambian Government/MRC Unit Joint Ethics Committee on the 16<sup>th</sup>  
6 May 2017 (SCC1479v2) and by the Department of Biosciences Ethics Committee at  
7 [institution name removed for purpose of anonymous peer review].

8

9 [Figure 1]

10 [Figure 2]

## 11 Results

12

### 13 *Canine-human relations in The Gambia*

14 Free-roaming dogs are ubiquitous across The Gambia. So-called ‘modern village  
15 dogs’<sup>25-26</sup> – brown, short-haired, of small-medium build (Figure 3) – can be seen  
16 wandering dusty roads and paths, perched outside market stalls, and panting  
17 underneath mango trees to escape the midday heat. Almost all dogs roam freely and  
18 fall into two broad categories: those owned by a family compound (and kept for  
19 security, company, and sometimes for hunting) and, as many locals described, a  
20 growing stray population. Stray dogs across rural and urban areas were widely  
21 considered to be a nuisance. Focus group participants noted their unpredictability  
22 and potential to bite, prey on livestock, and even to exhume recently-buried bodies  
23 from cemeteries. Owned dogs could also bite, and some interviewees in the urban  
24 sites mentioned the high-profile case of the (then) President-Elect Adama Barrow’s

1 son being mauled to death by family-owned dogs (January 2017).<sup>27-28</sup> For these  
2 reasons there was a general (pre-exposure) consensus among research participants  
3 that they would not approach a stray dog and would not invite an unfamiliar dog to  
4 sniff them because, a consensus was, ‘the likelihood of a bite is there.’

5

#### 6 *Introducing a mock-up BDD*

7       Large audiences gathered to observe the mock-up BDD — an unfamiliar  
8 companion-dog being walked on a leash by foreigners — during our FGDs and  
9 compound visits. It is extremely rare to see a dog being walked on a leash, or  
10 otherwise constrained, in The Gambia. However, compound-owned dogs (used  
11 generally for security) are considered to be *under control* despite being free-  
12 roaming. The use of a leash and harness to manage the working dog therefore raised  
13 suspicions of some residents, who interpreted the dog as being *uncontrolled*: likely  
14 to bite if not firmly held by the handler and thus a threat to safety.

15       Despite initial wariness, however, most study participants found the actual  
16 dog much less intimidating than they had expected. One Serahuli woman, for  
17 example, summed up the feelings of others in her focus group when she said:

18       Since the dog has been here with us it hasn’t done anything and they are  
19 comfortable. For me seeing that, I have confidence that the dog will not  
20 do anything to me. I can get close to the dog with no problem.  
21

22       It was important for many not to get *too close*, however, as this paper goes  
23 on to discuss.

24

1 The German Shepherd Dog was an unfamiliar and ‘foreign’ breed for study  
2 participants. This initially caused some scepticism; for example, one Serahuli man  
3 (pre-exposure) asserted, *‘I would not want to be sniffed by any of these dogs because*  
4 *these are not the type of dogs we usually see here. They are only in the West.’* When  
5 introduced to the ‘foreign’ dog, however, there was a palpable shift in perception. As  
6 one Fula women put it, *‘I will not refuse that [being sniffed], because our own dogs*  
7 *are different from this one because of training — our dogs are not trained.’*

**[Figure 3]**

10 *Dogs and malaria diagnostics: perceptions of safety and efficacy*

11 RDTs are the principal method for malaria diagnosis in the study sites. Most study

12 participants believed RDTs to be a largely safe and effective diagnostic method but

13 there were widespread concerns – and sometimes fears – about their invasive

14 nature and the pain associated with using a blood lancet. One Mandinka mother, for

15 instance, said, *'I am very scared of [finger] pricking: when my child is being pricked, I*

16 *hold him close to my body because I feel it for the child.'* Another (Serahuli) woman

17 recalled how *'We were being pricked for blood samples, I did accept it but I was*

18 *uncomfortable with the amount of blood being taken for the test. I could see the*

19 *blood coming from the fingertip and that was not something I was comfortable with.'*

20 In the light of this, most participants welcomed the possibility of a non-invasive

21 diagnostic test. In the words of one Mandinka woman, *'If there is a dog that can sniff*

22 *and know your problem or there is a needle that can prick you, which one are you*

23 *going to pick? I'm going to pick the dog!'*

1           In all five focus groups, however, concerns were expressed about safety and  
2 efficacy. Most prominent among these were anxieties about being bitten,  
3 particularly in a context where rabies remains endemic. One Fula male elder, for  
4 example, had serious reservations; his child had recently died shortly after being  
5 mauled by a dog and contracting ‘mad dog disease’ (suspected rabies). This, and  
6 similar accounts, led some to suggest the use of canine muzzles. Others did not  
7 object in principle but did not like the idea of a dog being *inside* (a health centre, for  
8 example); in The Gambia, dogs always stay outdoors. Some focus group participants  
9 also queried the *reliability* of BDDs compared with the more familiar RDTs, which  
10 were associated with health professionals and ‘modern’ clinics. Dogs and their  
11 handlers did not share this same professional status. Overall, participants wanted  
12 reassurance over both safety and capability, summed up eloquently by this Bambara  
13 mother:

14           I would not trust the dog sniffing the child unless I was assured that the  
15 dog would not do anything but sniff. If that assurance and guarantee is  
16 given to me, then I can allow the dog to sniff my child. Based on that  
17 trust, that guarantee, and the fact that you have given me a strong word  
18 that the dog will not do anything but sniff and not bite — then I would  
19 accept.  
20

21

## 22   *Socio-cultural considerations*

23   In addition to questions about efficacy and physical safety, social and religious  
24 concerns about BDDs were also widely raised. Interpretations of Islamic teachings  
25 pertaining to impurity (Arabic, *najasa*) were often mobilised as an instruction for  
26 Muslims not to keep dogs, and some Muslim study participants considered it *haram*  
27 (forbidden) to touch a dog. Of particular concern was saliva: several participants

1 explained that, according to Islamic teaching, cooking pots and utensils needed to be  
2 washed seven times if sniffed or licked by a dog. Such concerns were not exclusive to  
3 the Muslim majority population. A Christian priest declared that The Gambia (in  
4 general) was '*not a dog-loving community to the extreme that you have in the West.*'  
5 Although many Christians keep dogs for security and are Biblically-mandated to care  
6 for animals, he contrasted dog ownership in The Gambia with the '*lovey-dovey*  
7 *relationship that you have in England.*'

8

9         In practice, however, there was considerable ambivalence and negotiation,  
10 with practical concerns often overriding religious ones. In rural areas, for example,  
11 many Muslim participants kept dogs for guarding family compounds and hunting.  
12 Likewise, among the rising middle classes, dogs are seen as an effective (and perhaps  
13 more reliable) alternative to hiring a night watchman. Interestingly, a Mandinka  
14 *Imam* (religious authority) in the WCR maintained that, while dog *saliva* was *haram*,  
15 being *sniffed* by a BDD would not violate pre-prayer ablutions. In fact, he strongly  
16 supported their potential use for protecting people's health. A Serahuli *Imam* (WCR)  
17 corroborated this view, '*if you train a dog to sniff malaria, if that's the intention, you*  
18 *can do it.*'

19

## 20 **Discussion**

21 The findings presented in this paper give cause for optimism that BDDs could be an  
22 acceptable diagnostic technology even in populations in the Global South that are  
23 not normally regarded as 'dog friendly.' Despite some concerns, most study  
24 participants (men and women, from a range of religious and ethnic backgrounds)

1 were favourably disposed to their potential use, at least in principle. Crucially, BDDs  
2 offered the possibility of a non-invasive malaria test, less painful than current  
3 diagnostic technologies.

4

5         These findings also underline the importance of understanding and  
6 addressing local concerns, many of which are rooted in very real and reasonable  
7 apprehensions, for example, about the risk of biting in a rabies-endemic country.  
8 Several focus-group participants proactively suggested possible solutions or  
9 mitigations, such as the ideas of equipping dogs with muzzles (although this would  
10 need careful trialling to ensure that the ability to detect volatiles would not be  
11 impaired). Religious injunctions also featured prominently among the concerns of  
12 Muslim participants in particular, but in practice there was substantial flexibility in  
13 interpretation, and many people took a pragmatic view of how to manage  
14 interactions with dogs without compromising their religious integrity. The Imam who  
15 distinguished ‘sniffing’ from the (forbidden) contact with saliva, provides an  
16 excellent example of this. Context was also shown to be important in this study:  
17 *what kind* of dog and *where* (inside/outside) both mattered to different participants.

18

19         These specific findings may not be generalisable beyond the immediate  
20 context of The Gambia. They do, however, underline, the wider importance of  
21 working with local people to understand and address their concerns before  
22 deploying a novel technology. In the case of BDDs, it is important to understand the  
23 wider context of canine-human relationships, and how these might be inflected by  
24 factors such as the appearance of the dog and handler, the location, the proximity

1 and the most appropriate method (sample/line-up). The reaction of *Imams*, who  
2 took pragmatic views in the interests of protecting health, also underscores the  
3 value of working with local religious and other community leaders whose  
4 endorsement and input into accompanying awareness-raising initiatives can be  
5 crucial.

6

7

## 8 **Conclusion**

9 This study has provided a useful insight into a potentially important global health  
10 innovation: the use of BDDs as a mobile diagnostic method in LMICs, particularly at  
11 ports of entry in malaria-free countries. Specifically, it signposts issues likely to arise  
12 when BDDs are applied in the very different social landscapes of the Global South  
13 compared to current use in HIC settings, and highlights the importance of working  
14 *with* local communities and opinion leaders to identify and address their concerns.

15

16 As an exploratory study, our work has significant limitations: it was carried out over a  
17 relatively short time period (six weeks) among a non-representative population in  
18 pre-selected settlements in The Gambia. Research conducted over a larger  
19 geographical area, over a longer period of time, with a greater diversity of  
20 participants, might have identified other issues and concerns. It is also important to  
21 recognise that social acceptability is only one of many hurdles that must be  
22 addressed for BDDs to be used at scale as diagnostic tools in the Global South. Even  
23 in high-income countries, their use remains limited, at least partly because of the

1 substantial time and financial costs of breeding, training and looking after BDDs over  
2 the long-term.

3

4 Nonetheless, this study – and the accompanying proof-of-concept work – highlights  
5 the potential for using BDDs for diagnostic screening in LMIC settings. While the  
6 focus of this study has been specifically on malaria, the implications of possible BDD  
7 deployment are far-reaching in a continent where a chronic lack of diagnostic  
8 technology represents a major impediment to improving healthcare, particularly in  
9 the context of rising burdens of cancer and other non-communicable diseases.<sup>29-31</sup> If  
10 that potential is to be realised, it is crucial that clinical/scientific research and  
11 development go hand-in-hand with social research to ensure that interventions are  
12 appropriately designed, in consultation with the intended beneficiaries.

### 13 **Disclosure statements**

14

### 15 **Ethics approval and consent to participate**

16 The study was approved by the Gambian Government/MRC Unit Joint Ethics  
17 Committee on the 16<sup>th</sup> May 2017 (SCC1479v2) and by the Department of Biosciences  
18 Ethics Committee at Durham University.

19

### 20 **Consent for publication**

21 MRCG fieldworkers obtained informed consent (including consent for publication) in  
22 the relevant languages (Mandinka, Fula, and Serahuli) of participants.

23

### 24 **Competing interests**

25 The authors declare that they have no competing interests.

26

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29

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**Figure 1: Map of The Gambia featuring primary fieldsites, WCR and URR.**  
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**Figure 2: Exploring local perceptions of dogs and handlers.**

**Figure 3: Free-roaming Gambian dogs, WCR.**

